

**What is claimed is:**

1. A method for measuring performance of a storage device for storing data to and/or retrieving data from the storage device, comprising the steps of:

5 (a) specifying one or more access patterns for transferring data to/from the storage device;

(b) specifying one or more different required data transfer rates; and

(c) for each access pattern: measuring the actual data transfer time of the storage device for transferring said data according to that access pattern, and  
10 determining performance of the storage device in relation to at least one required data transfer rate as a function of: that required data transfer rate and the actual data transfer time of data for that access pattern.

15 2. The method of claim 1, wherein step (c) for each access pattern further includes the steps of:

determining performance of the storage device in relation to each required data transfer rate for that access pattern as a function of that required data transfer rate and the actual data transfer time of data for said access pattern.

20 3. The method of claim 2, wherein step (c) for each access pattern further includes the steps of:

determining the amount of data transfer required according to each data transfer rate during the actual data transfer time of that access pattern; and

25 determining performance of the storage device in relation to each data transfer rate as a function of: (1) the actual data transfer time for that access pattern, and (2) each required data transfer rate and corresponding amount of data transfer required for that data transfer rate for that access pattern.

4. The method of claim 3, wherein step (c) for each access pattern further includes the steps of, for each data transfer rate: determining the difference between the required amount of data transfer for that data transfer rate and the actual amount of data transferred, during said actual data transfer time for that access pattern, and  
5 determining the performance of the storage device as a function of said difference.

5. The method of claim 1, wherein:  
step (a) further includes specifying each access pattern to include one or more data transfer commands, wherein each command is for transferring one or more  
10 data blocks from/to the storage device; and

step (c) for each access pattern further includes the steps of, for each data transfer command for that access pattern: measuring the actual data transfer time for the storage device to transfer data blocks for that command, and determining performance of the storage device in relation to each data transfer rate as a function of  
15 that required data transfer rate and the actual data transfer time for that command.

6. The method of claim 5, wherein step (c) for each access pattern further includes the steps of:

for each data transfer command for that access pattern: determining  
20 amount of data transfer required according to each data transfer rate during the actual data transfer time of that data transfer command, and determining performance of the storage device in relation to each data transfer rate as a function of the required amount of data transfer for that data transfer rate and actual amount of data transferred, during the transfer time for that transfer command.

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7. The method of claim 6, wherein step (c) for each access pattern further includes the steps of, for each transfer command of that access pattern:

for each data transfer rate:

determining the difference between (1) the required amount of data transfer for that data transfer rate and (2) the actual amount of data transferred, during the data transfer time of that data transfer command; and

5 determining the performance of the storage device in relation to that data transfer rate as a function of said measured difference.

8. The method of claim 1, wherein:

step (b) further includes the steps of maintaining an adjustable virtual buffer size value corresponding to each required data transfer rate; and

10 step (c) for each access pattern further includes the steps of, for each required data transfer rate:

determining the amount of data transfer required according to that data transfer rate during the data transfer time of that access pattern;

15 determining the difference between the required amount of data transfer and the actual amount of data transferred according to that access pattern; and

adjusting the virtual buffer size value for that data transfer rate based on said difference.

20 9. The method of claim 8, wherein a buffer selected based on one or more of the adjusted virtual buffer size values for each data transfer rate per access pattern, allows streaming data to/from the storage device via the buffer at least at that required data transfer rate for that access pattern.

25 10. The method of claim 8, further comprising the steps of selecting data storage patterns on the disk drive based at least on one or more of said data transfer times per access pattern, to increase data transfer performance of the disk drive.

11. The method of claim 8, further comprising the steps of selecting a buffer

size for each data transfer rate based at least one or more of the adjusted virtual buffer size values of that data transfer rate, to increase data transfer performance of the disk drive.

5           12.    The method of claim 1, wherein:

                  step (a) further includes specifying each access pattern to include one or more data transfer commands, wherein each command is for transferring one or more data blocks from/to the storage device;

                  step (b) further includes the steps of maintaining an adjustable virtual  
10   buffer size value corresponding to each required data transfer rate; and

                  step (c) for each access pattern further includes the steps of, for each data transfer command for that access pattern:

                                measuring the actual data transfer time of the storage device to transfer data blocks for that command;

15                         for each data transfer rate:

  determining the amount of data transfer required according to that required data transfer rate during the data transfer time of that transfer command;

20                                 determining the difference between the required amount of data transfer and the actual amount of data transferred according to transfer command; and

  adjusting the virtual buffer size value for that data transfer rate based on said difference.

25           13.    The method of claim 12, wherein a buffer selected based on one or more of the adjusted virtual buffer size values for each data transfer rate per access pattern, allows streaming data to/from the storage device via the buffer at least at that required data transfer rate for that access pattern.



drive including at least one data disk having multiple concentric data tracks thereon for storing data, and at least one transducer radially moveable relative to said data tracks by an actuator for transferring data to/from the concentric data tracks.

5           22. The method of claim 1, wherein each of the required data transfer rates is a constant data streaming rate to/from the storage device.

10           23. An apparatus for measuring performance of a storage device for transferring data to/from the storage device according to one or more access patterns in relation to one or more data transfer rates, each access pattern including one or more data transfer commands for transferring data to/from the storage device, comprising:

- 15                   (a) a storage device interface for communicating with the storage device;
- (b) control means for issuing each transfer command per access pattern to the storage device via the storage device interface;
- (c) timing means for measuring the actual data transfer time of the storage device for transferring data according to each command; and
- 20                   (d) processing means for determining performance of the storage device for each transfer command per access pattern in relation to each data transfer rate, as a function of that required data transfer rate and the actual data transfer time of that transfer command.

25           24. The apparatus of claim 23, wherein the processing means further includes:

                  means for determining the amount of data transfer required according to each data transfer rate during the actual data transfer time of each transfer command per access pattern; and

means for determining performance of the storage device for each data transfer rate for each transfer command per access pattern as a function of: (1) the actual data transfer time for that transfer command, and (2) that required data transfer rate and said amount of data transfer required for that data transfer rate.

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25. The apparatus of claim 23, wherein the processing means further includes:

means for determining the amount of data transfer required according to each data transfer rate during the actual data transfer time of each transfer command per access pattern; and

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means for determining, for each data transfer rate:

the difference between the required amount of data transfer for that data transfer rate and the actual amount of data transferred, during said actual data transfer time for each transfer command per access pattern; and

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the performance of the storage device as a function of said difference.

26. The apparatus of claim 23 further comprising means for maintaining an adjustable virtual buffer size value corresponding to each required data transfer rate, and wherein the processing means further includes:

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means for determining the amount of data transfer required according to each data transfer rate during the actual data transfer time of each transfer command per access pattern; and

means for determining, for each data transfer rate:

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the difference between the required amount of data transfer or that data transfer rate and the actual amount of data transferred, during said actual data transfer time for each transfer command per access pattern; and

adjusting the virtual buffer size value for that data transfer rate

based on said difference.

27. The apparatus of claim 23, wherein a buffer selected based on one or more of the adjusted virtual buffer size values for each data transfer rate per access pattern, allows streaming data to/from the storage device via the buffer at least at that  
5 required data transfer rate for that access pattern.

28. The apparatus of claim 23, wherein the storage device comprises rotatable media for storing data.

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29. The apparatus of claim 28, wherein each access pattern includes parameters location of data in the storage media for transfer.

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30. The apparatus of claim 29, wherein at least one access pattern comprises sequential access for transferring data to/from at least one contiguous location on the media.

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31. The apparatus of claim 29, wherein at least one access pattern comprises multiple stream access for transferring data to/from different locations on the media for each data stream.

32. The apparatus of claim 32, wherein the data streams are interleaved in time and location.

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33. The apparatus of claim 32, wherein the multiple stream access comprises a multiple random stream access for transferring data to/from different locations on the media for each data stream.



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38. The computer readable medium of claim 37, further comprising means, provided on the computer-readable medium, for determining the amount of data transfer required according to each data transfer rate during the actual data transfer time of each transfer command per access pattern;

wherein said means for determining performance of the storage device further includes means for determining performance of the storage device for each data transfer rate for each transfer command per access pattern as a function of: (1) the actual data transfer time for that transfer command, and (2) that required data transfer rate and said amount of data transfer required for that data transfer rate.

39. The computer readable medium of claim 37 further comprising means, provided on the computer readable medium, for determining the amount of data transfer required according to each data transfer rate during the actual data transfer time of each transfer command per access pattern;

wherein said means for determining performance of the storage device, further includes means for determining, for each data transfer rate:

the difference between the required amount of data transfer for that data transfer rate and the actual amount of data transferred, during said actual data transfer time for each transfer command per access pattern; and

the performance of the storage device as a function of said difference.

40. The computer readable medium of claim 37 further comprising means, provided on the computer readable medium, for maintaining an adjustable virtual buffer size value corresponding to each required data transfer rate;

wherein said means for determining performance of the storage device, further includes:

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wherein a buffer selected based on one or more of the adjusted virtual buffer size values for each data transfer rate per access pattern, allows streaming data to/from the storage device via the buffer at least at that required data transfer rate for that access pattern.